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under the direction of

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INTRODUCTION

This program is concerned with new methods of generating and detecting far infrared radiation and with their applications to problems of physical interest. The over-all purpose is to advance the technology of the infrared region so that it may become as accessible for scientific investigations as the radio and optical portions of the spectrum.

PRESENT STATUS

The investigation began with consideration of the CN radical, which had been reported as the active species of a coherent infrared gas discharge source. It was realized that a free radical, having an unpaired electron, must show a substantial Zeeman effect in a magnetic field. This should make it possible to achieve substantial tunability by applying an axial magnetic field to the gas laser.

A commercial cyanide laser was purchased. Unexpected difficulties were encountered in getting it to oscillate. The provision for making the mirrors parallel was quite inadequate. Modifications were made to permit the use of a visible gas laser in the alignment process. Also, one of the flat mirrors was replaced by a spherical mirror so that its angular position was less critical. Modifications were also made to the vacuum system. Dial gauges were provided for measuring mirror motion. Output was taken from the variable coupling mirror originally installed. Much work was required to shield the detector electronics from the intense electrical noise generated by the laser spark discharge. After considerable effort, satisfactory laser action was achieved, presumably on the 337 micron line attributed to the CN radical.

Meanwhile, however, other reports have appeared which show that the laser wavelengths produced in cyanide discharges can not be attributed to CN radicals. Stafsudd, Haak and Radisavljevic,[1] have shown that hydrogen must be present in the discharge, and that the wavelength is drastically changed when deuterium is substituted for hydrogen. Hocker, et al.,[2] have shown that the output frequency of a continuous-wave cyanide discharge laser does not change or split when a magnetic field is applied. Furthermore, they have made a precise measurement of the laser output frequency. With it, Lide and Maki[3] have been able to make a positive identification of HCN as the lasing species.

It is now clear that the active material in cyanide lasers is not the CN or any other free radical. Thus, cyanide lasers are not suitable for magnetic tuning. It is quite possible, indeed rather likely, that lasers using radicals can and will be found. However, for the moment our attention is directed to other aspects of the problem of generating coherent far-infrared radiation.

In particular, we have become aware that the discharge plasma has a more important effect on the propagation of submillimeter waves than it has on the near-visible radiation. Moreover, in pulsed lasers the discharge current produces a magnetic field large enough to cause the plasma to become doubly refracting to some extent.

It may well be that plasma refraction and absorption can account for some anomalies which have been reported. Thus, Sochor and Brannen[4] have noted that in high-voltage pulsed lasers the laser output pulse generally comes at or even after the end of the current pulse. Brannen, et al.,[5] note for the water vapor laser the possibility that this could be associated with the electron density. Indeed, reasonable values for the plasma density could cause the discharge to be opaque to the submillimeter waves. This would cause a self Q-switching, only after enough ions and electrons have recombined.

Another anomalous result has been an apparent small splitting of the laser frequency, which has been observed in some pulsed cyanide lasers.[6] What was actually observed, however, was that laser action occurred at two different spacings of the laser mirrors for each axial mode. An alternative explanation is that the magneto-plasma double-refraction establishes two different polarization modes, one with basically radical electric fields and the other with basically circumferential fields. A very slight difference in the refractive index for these two modes would show up as different mirror spacings for each, as the mirror spacing, D, at resonance is given by $D = p\lambda_0/2n$, where p is a large integer, λ_0 is the free-space wavelength and n is the refractive index.

Estimates of the magnitude of the plasma effects involve the plasma density which is usually not measured. Reasonable values of plasma density indicate that they can be very important. Further studies of the effects of the plasma and discharge current are under way. It is planned to elucidate the effects and find out under what circumstances they occur.

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